Motivation

Introduction

Motivation can be thought of as a driving force on behavior. The probability and direction of a behavior will vary with the level of driving force to perform that behavior.

- Appropriately gate the expression of behaviors that have conflicting goals.

The Hypothalamus, Homeostasis, and Motivated Behavior

The hypothalamus plays a key role in the regulation of body temperature, fluid balance, and energy balance.

- Hormonal responses – respond to sensory signals by controlling the release of pituitary hormones.
- Visceromotor responses – respond to sensory signals by controlling the sympathetic and parasympathetic responses.
- Somatic motor responses – respond to sensory signals by eliciting appropriate behavioral responses.

The Long Term Regulation of Feeding Behavior

One primary reason we eat is to keep energy stores at a sufficient level.

Energy Balance

- The body’s energy stores are replenished during and immediately after eating.
  - Absorptive metabolism.
  - Food is stored as glycogen, triglycerides, and protein.
- Between meals energy is retrieved from the stores.
  - Postabsorptive metabolism.
  - Glycogen and triglycerides are broken down to glucose, fatty acids and ketones.

Hormonal and Hypothalamic Regulation of Body Fat and Feeding

Feeding is stimulated when hypothalamic cells in the periventricular zone detect a drop in the level of a hormone released by fat cells.

Body Fat and Food Consumption

- Fat cells (adipocytes) filled with fat (lipids) produce the hormone leptin.
  - More lipids – more leptin
  - Less lipids – less leptin

The Hypothalamus and Feeding

- Lesions of the lateral hypothalamus cause anorexia (weight loss).
- Lesions of the ventromedial hypothalamus cause obesity (weight gain).
- Leptin bind to receptors of neurons in the arcuate nucleus (ventromedial hypothalamus).

The Effects of Elevated Leptin Levels on the Hypothalamus

- Neurons in the arcuate nucleus with αMSH and CART are activated by a rise in leptin.
- (Neurons in the arcuate nucleus with NPY and AgRP are turned off by a rise in leptin.)
- Activated αMSH and CART neurons:
  - Inhibit neurons in the lateral hypothalamus and suppress feeding.
  - Activate the sympathetic nervous system and increase metabolic rate.
  - Activate neurons in the paraventricular nucleus causing an increased release of corticotropin (ACTH) and thyrotropin (TSH) from the anterior pituitary.
    - ACTH stimulates release of cortisol from the adrenal gland.
    - TSH stimulates release of thyroxin from the thyroid gland.

The Effects of Decreased Leptin Levels on the Hypothalamus

- Neurons in the arcuate nucleus with NPY and AgRP are activated by a fall in leptin.
- (Neurons in the arcuate nucleus with αMSH and CART are turned off by a fall in leptin.)
- Activated NPY and AgRP neurons:
  - Activate neurons in the lateral hypothalamus and stimulate feeding.
  - Activate the parasympathetic nervous system.
  - Inhibit neurons in the paraventricular nucleus causing a decreased release of corticotropin (ACTH) and thyrotropin (TSH) from the anterior pituitary.

The Control of Feeding by Lateral Hypothalamic Peptides

- There are at least two groups of neurons in the lateral hypothalamus that respond to the leptin sensitive neurons in the arcuate nucleus.
  - Neurons with MCH that have widespread connections in the brain, including the cerebral cortex.
  - Neurons with orexin that also have widespread cortical connections.
- Both of these groups of neurons appear to be involved in inducing feeding.

The Short-Term Regulation of Feeding Behavior

Although leptin plays a critical role in control of feeding behavior, the control of eating just before, during, and just after a meal involves other, more rapidly acting factors.

Appetite, Eating, Digestion, and Satiety

- Cephalic phase
    - Stomach is empty and secreting the hormone ghrelin
    - The sight and smell of food stimulates the parasympathetic nervous system and enteric nervous system causing the secretion of saliva in the mouth and digestive juices in the stomach.
- Gastric phase
    - Food is chewed, swallowed, and moved into the stomach.
    - The stomach secretes various hormones.
- Intestinal (substrate) phase
    - Partially digested food moves into the intestines, digestion continues, and nutrients are absorbed into the blood.
    - The intestines secrete various hormones.

Ghrelin

- The peptide hormone ghrelin is produced by the stomach wall and is released into the blood when the stomach is empty.
- Ghrelin activates the NPY and AgRP neurons of the arcuate nucleus of the hypothalamus and stimulates appetite and food consumption.

Taste and Smell of Food

- The taste of food activates taste buds that activate sensory axons in the facial and glossopharyngeal nerves.
- Facial and glossopharyngeal sensory neurons activate neurons in the gustatory nucleus (an anterior solitary tract nucleus) and provide a signal to maintain appetite and food consumption.

Gastric Distension

- Filling of the stomach activates mechanoreceptors of sensory axons in the vagus nerve.
- Vagal sensory neurons activate neurons in the nucleus of the solitary tract and provide a signal to inhibit appetite and food consumption.

Cholecystokinin

- Filling of the small intestine with food (especially fatty foods) stimulates secretion of cholecystokinin from the duodenum.
- Cholecystokinin stimulates axons of the vagus nerve and inhibits appetite and food consumption.

Insulin

- Increases in blood glucose and activation of the parasympathetic nervous system stimulate beta cells of the pancreas to release insulin.
- Increases in insulin activate the αMSH and CART neurons of the arcuate nucleus of the hypothalamus and inhibits appetite and food consumption.

Why Do We Eat?

We appear to eat through a combination of “wanting” (or needing) food and “liking” food. “Wanting” food can be classified as a drive-reduction, satisfying a craving. “Liking” food can be thought of as pleasurable response to eating.

Reinforcement and Reward

Effective sites for electrical self-stimulation have been found along the trajectory of dopamine neurons from the ventral tegmental area projecting to the forebrain. Electrical self-stimulation apparently provides a reward that reinforces the pressing of a lever.

The Role of Dopamine in Motivation

There is little doubt that dopamine release in the brain will reinforce the behavior that causes it.

- Feeding releases dopamine in the brain.
- Dopamine reinforces the feeding behavior.

Serotonin, Food, and Mood

Serotonin release in the brain induces the feeling of pleasure.

- Serotonin levels in the brain are low between meals.
- Serotonin rises in anticipation of food and peaks during eating (especially carbs).
- Serotonin induces the feeling of pleasure during feeding behavior.

Other Motivated Behaviors

Drinking Fluids

Maintaining water and electrolyte balance is critical for cellular and body function.

Decreased Body Fluid Volume

- Decreased body fluid volume causes decreased filling of the heart and blood vessels.
- Decreased filling of the heart and blood vessels is measured by mechanoreceptors of sensory axons in the vagus nerve.
- Decreased activity of these vagal sensory neurons activates neurons in the nucleus of the solitary tract and provides a signal to activate the sympathetic nervous system and to directly stimulate thirst and water seeking behavior.
- In addition stimulation of the sympathetic nervous system causes increased production of angiotensin II which activates the subfornical organ of the hypothalamus and causes increased secretion vasopressin, thirst and water seeking behavior.

Increased Electrolyte Concentration and/or Dehydration

- Increased electrolyte concentration and/or dehydration increases blood osmolality.
- Increased blood osmolality in the liver is measured by osmoreceptors of sensory axons in the vagus nerve.
- Increased blood osmolality is also measured by the OVLT (in the lining of third ventricle of hypothalamus).
- Increased activity of these vagal sensory neurons activates neurons in the nucleus of the solitary tract and together with the signals from the OVLT provides a signal to stimulate thirst and water seeking behavior.

Temperature Regulation

Core body temperature must be maintained near 37C.

- Core body temperature is measured by thermoreceptors in the anterior hypothalamus.
- Hormonal and visceromotor responses are integrated by the medial preoptic nucleus.
- Decreased body temperature causes an increase in TRH from the hypothalamus, an increase in release of TSH from the anterior pituitary, and thus an increase in thyroxin from the thyroid gland.
- Thyroxin increases cellular metabolism, energy usage and heat production, causing warming of the body.
- Decreased body temperature also causes an increase in somatic motor and sympathetic activity producing shivering, peripheral vasoconstriction, and heat seeking behavior.